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Advanced Impact Analysis: the ADVIAN® method - an enhanced approach for the analysis of impact strengths with the consideration of indirect relations

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Keywords

ADVIAN, direct impact, impact analysis, impact factor, impact matrix, indirect impact, MICMAC

Abstract

An enhanced approach for the impact analysis is presented. Impact analyses play an important role in future research analysis as part of the scenario techniques in the strategic management field. Nowadays, they are also applied for the description of mutual relationships of tangible and intangible resources in organisations. The new method is based on currently existing methods using a cross impact matrix and overcomes some of their drawbacks. Indirect impacts are considered together with their impact strengths. A modification of the impact matrix is not necessary. Simple examples show that the new method leads to more reasonable and stable results than the existing methods. The new method shall help analysing the complexity of social systems in a more reliable way.

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1. Introduction

Impact analysis methods provide a number of methodical efforts to the analysis and numerical depiction of the complexity of social systems. They employ a 'system-metaphor' to make the system elements and their interdependencies comprehensible and understandable [1]. Impact analysis aims to support organisations to explore current organisational challenges and to prepare decisions for future endeavours in a participatory manner. In the past, impact analysis has been used within future research and scenario techniques [2, 3]. Nowadays, impact analysis is also applied to map the relationships of intangible and tangible resources within performance measurements [4, 5].

Impact analyses are characterisation methods. The impact analysis methods have been utilised to find out the relationship between the impact factors (IFs; sometimes also named resources or influencing factors) and to draw conclusions as to which impact factors are the most important in order to influence the whole system; in other words which impact factors are the key to optimise the system. Impact analyses follow a similar proceeding: (A) identifying impact factors, (B) scoring of mutual, direct influence of impact factors in a participatory way, (C) calculating the direct and indirect interdependencies and, finally, (D) classifying these impact factors according to several criteria for further organisational decisions and activities. The identification of impact factors, as well as the assignment of the impact strengths of the impact factors on each other in step (A) and (B), are difficult challenges but are indeed necessary steps taken in order to characterise the system. One method is to arrange the impact factors in a cross impact matrix (CIM or just impact matrix, IM). The dimension of this matrix is the number of IFs squared and it contains the impact strengths of every IF on every other IF. The idea of a cross impact matrix has been known for decades [6, 7]. However, the identification and scoring of the IFs in an impact matrix are not in the focus of this paper. In this article we will focus on step (C). Step (D) will be the topic of another paper [8]. For the calculation of interdependencies simple mathematical operations are applied to the elements of the matrix. The most important approaches used thus far include the sum of the elements in the rows and the sum of the elements in the columns of the IM. However, the simple formation of sums does not consider indirect impacts. There are methods for the consideration of indirect impacts as well (e.g. [9]) but with other drawbacks shown below. Therefore, it is necessary to improve the present methods.

This paper develops the existing methods further and additionally considers the indirect interactions in a more reliable way. We want to apply improved quantitative methods to investigate interdependencies. Therefore this new and refined method has been named ADVanced Impact ANalysis (ADVIAN®). The basics of this method were developed in 2005 [10] and first used for a project in the software industry in 2006 [11]. In the present paper, we will first give a summary on the most important existing methods and then introduce the ADVIAN® method. A direct comparison between the state of the art of the methods and the new ADVIAN® method will show the improvements reached thus far.

Before going into detail, it should be noted explicitly that the impact analysis itself only provides a measure of the interaction between the impact factors and not a measure of the condition of the impact factors. Therefore the result of the impact analysis determines which impact factors are the most important ones for the performance of the whole system but the impact analysis does not give a current status of the system. Furthermore, the identified IFs may be the most important for the regular operation of a system (for instance documentation in the software industry [11]) but not the most important for the product of the system (design of the software [11]).

2. Impact Analysis - state of the art

This chapter shall give a short summary and some examples for the state of the art of impact analysis. The identification of impact factors and the assignment of their impact strengths are not a topic of this paper (see for instance [12]). The following methods assume that the cross impact matrix has already been filled: a suitable set of impact factors is already chosen and the direct impact strength of each impact factor on all other IFs has already been classified by the strength 0 (no impact), 1 (little impact), 2 (medium impact), or 3 (strong impact). This is normally done in a participatory way in e.g. strategic work groups [1].

Several methods have been applied in the impact analysis such as the „Papiercomputer“ (Engl. paper computer [13]), the MICMAC method (Matrice d'Impacts Croisés Multiplication Appliquée à un Classement [9]), a fuzzy approach [14] or even a method that comes without the impact matrix (GAMMA [15]). We will focus on the impact matrix and we will address the first two methods because they are the most commonly used. The „Papiercomputer“ only takes direct impacts into account while the MICMAC method considers the indirect impacts.

We will choose a small example with 10 IFs from literature for demonstration (taken from [16]). Usually, the examples given in literature are either not completely given [12, 17] and/or consider more than 20 IFs [14, 18].

In the following we will use the abbreviation IF1⇒IF2 for ‘the impact of impact factor 1 on impact factor 2’.

2.1 Impact analysis with active and passive sums (Vester, „Papiercomputer“)

Vester calls the impact matrix „Papiercomputer“ („paper computer“) [13]. An example of an impact matrix is given in the next figure [16]. The rows of the impact matrix contain the impact strengths of a considered IF on all other IFs (being arranged in the columns).

	IF1	IF2	IF3	IF4	IF5	IF6	IF7	IF8	IF9	IF10	AS
IF1	**x**	**3**	**1**	**3**	**0**	**0**	**2**	**2**	**0**	**1**	12
IF2	**1**	**x**	**3**	**0**	**2**	**1**	**0**	**1**	**0**	**0**	8
IF3	**0**	**2**	**x**	**0**	**3**	**2**	**0**	**0**	**0**	**0**	7
IF4	**0**	**3**	**3**	**x**	**0**	**0**	**2**	**0**	**0**	**0**	8
IF5	**0**	**0**	**0**	**0**	**x**	**0**	**0**	**2**	**0**	**0**	2
IF6	**3**	**0**	**0**	**0**	**1**	**x**	**2**	**1**	**0**	**0**	7
IF7	**1**	**1**	**1**	**1**	**0**	**2**	**x**	**1**	**0**	**2**	9
IF8	**0**	**0**	**1**	**1**	**0**	**0**	**0**	**x**	**0**	**1**	3
IF9	**1**	**3**	**0**	**3**	**0**	**0**	**0**	**0**	**x**	**2**	9
IF10	**3**	**3**	**3**	**2**	**0**	**1**	**3**	**3**	**1**	**x**	19
PS	9	15	12	10	6	6	9	10	1	6	

IF1 Legislation
IF2 Gross national product
IF3 Standard of living
IF4 Level of costs
IF5 Demand for mobility
IF6 Environmental awareness
IF7 Energy technology and alternative energy forms
IF8 Public transport system
IF9 International trading
IF10 Availability and price of crude oil

Figure 1: Impact matrix for a simple example (automotive industry, taken from [16], p. 146)

The main diagonal is filled with „x“ because by definition there is no impact from an impact factor on itself. After filling the IM the so-called active sum (AS) and passive sum (PS) is calculated. The active sum for a given impact factor is the sum over the elements in a row (all impact strengths on other IFs are summed up) and the passive sum is the sum over the elements in the column (all impact strengths from other IFs on the considered one are summed up). The active sum and passive sum give a first ranking of the IFs according to their importance in the system. IFs with high AS are considered very active because they have a strong impact on the other impact factors. IFs with a high PS are considered very influenced because the other IFs have a strong impact on them. A deeper evaluation of ranking of the IFs is the topic of another paper [8] and will not be discussed here in more detail. However, it is clear that the formation of the active and passive sum only does not take into consideration the indirect impacts and feedback loops. For instance, in the example there is no direct impact IF1⇒IF5. However, there are strong impacts IF1⇒IF2, IF2⇒IF3, IF3⇒IF5. This means there is the strong indirect impact IF1⇒IF2⇒IF3⇒IF5. Hub summarises the points of critique ([15], pp 108f.): The „Papiercomputer“ considers only the direct impacts. The indirect impacts however, which make the system a real mesh, are omitted. This may lead to a questionable ranking of the impact factors with regard to their importance in the system.

2.2 The consideration of indirect impacts: the MICMAC method

In the seventies Duperrin and Godet developed a method for indirect relationship analysis [9]. Nowadays, the method is known as MICMAC method. The method is based on an impact matrix as well. However, in the MICMAC matrix only the values „1“ (has impact) or „0“ (has no impact) are allowed. Since the example in figure 1 has the impact strengths 0, 1, 2, and 3 the impact matrix has to be modified. A common way to do this is to identify the strength 0 and 1 in the IM with 0 in the MICMAC matrix and the strength 2 and 3 in the IM with 1 in the MICMAC matrix. The first problem becomes obvious: weak impact strength is neglected and medium and strong impact strengths are set equal. Thus, the determination of the elements of the MICMAC matrix is linked with uncertainties [12].

The MICMAC method is based on a matrix multiplication. The MICMAC matrix (first matrix in figure 2) is multiplied by itself. This new matrix (second matrix in figure 2) contains the numbers of indirect impacts with the chain length 2. For instance, there are 2 indirect impacts from IF1 on IF3 (IF1⇒IF2⇒IF3 and IF1⇒IF4⇒IF3, see MICMAC matrix). If the resulting matrix is multiplied again with the MICMAC matrix the elements of the next matrix contain the numbers of indirect impact with the chain length 3 (third matrix in figure 2). In general, the MICMAC matrix raised to the power n results in a matrix containing the number of indirect impacts with the chain length n. The main diagonal of the MICMAC matrix is filled with 0 because there is no direct impact of an impact factor on itself. However, the main diagonals of all subsequent matrices may not be 0 because there may be indirect impacts of an impact factor on itself.

Similar to the „Papiercomputer“ the elements in the rows and columns are summed up. The higher the sum of the rows the higher the corresponding IF is ranked. This ranking may change the higher the power of the matrix is (the longer the chains of indirect impacts are). After a certain number of multiplication steps the ranking is supposed to be stable [9, 19]. Using the MICMAC method, Götze reports stability in ranking for the simple example from n=6 ([16], p. 149f.). However, comparing the matrices with the power 6 and 7 (see last two matrices in figure 3) this is valid only for the sums of the elements in the rows. There is still a change in the sums of the elements in the columns. Later on we will show that the stability of the ranking is not necessarily reached in every case.

	IF1	IF2	IF3	IF4	IF5	IF6	IF7	IF8	IF9	IF10	S	rank
IF1	**0**	**1**	**0**	**1**	**0**	**0**	**1**	**1**	**0**	**0**	**4**	2
IF2	**0**	**0**	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**2**	6
IF3	**0**	**1**	**0**	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**3**	3
IF4	**0**	**1**	**1**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**3**	3
IF5	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	9
IF6	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**2**	6
IF7	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**2**	6
IF8	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	10
IF9	**0**	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**3**	3
IF10	**1**	**1**	**1**	**1**	**0**	**0**	**1**	**1**	**0**	**0**	**6**	1
S	**2**	**5**	**3**	**3**	**2**	**2**	**4**	**3**	**0**	**2**		
rank	6	1	3	3	6	6	2	3	10	6		

	IF1	IF2	IF3	IF4	IF5	IF6	IF7	IF8	IF9	IF10	S	rank
IF1	**0**	**1**	**2**	**0**	**1**	**1**	**1**	**0**	**0**	**1**	**7**	4
IF2	**0**	**1**	**0**	**0**	**1**	**1**	**0**	**1**	**0**	**0**	**4**	8
IF3	**1**	**0**	**1**	**0**	**1**	**0**	**1**	**1**	**0**	**0**	**5**	7
IF4	**0**	**1**	**1**	**0**	**2**	**2**	**0**	**0**	**0**	**1**	**7**	4
IF5	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	9
IF6	**0**	**1**	**0**	**1**	**0**	**1**	**1**	**1**	**0**	**1**	**6**	6
IF7	**2**	**1**	**1**	**1**	**0**	**0**	**2**	**1**	**0**	**0**	**8**	3
IF8	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	9
IF9	**1**	**2**	**3**	**1**	**1**	**0**	**2**	**1**	**0**	**0**	**11**	2
IF10	**0**	**3**	**2**	**1**	**2**	**2**	**2**	**1**	**0**	**1**	**14**	1
S	**4**	**10**	**10**	**4**	**8**	**7**	**9**	**6**	**0**	**4**		
rank	7	1	1	7	4	5	3	6	10	7		

	IF1	IF2	IF3	IF4	IF5	IF6	IF7	IF8	IF9	IF10	S	rank
IF1	**2**	**3**	**2**	**1**	**3**	**3**	**2**	**2**	**0**	**1**	**19**	4
IF2	**1**	**0**	**1**	**0**	**1**	**0**	**1**	**1**	**0**	**0**	**5**	8
IF3	**0**	**2**	**0**	**1**	**1**	**2**	**1**	**2**	**0**	**1**	**10**	7
IF4	**3**	**2**	**2**	**1**	**2**	**1**	**3**	**3**	**0**	**0**	**17**	5
IF5	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	9
IF6	**2**	**2**	**3**	**1**	**1**	**1**	**3**	**1**	**0**	**1**	**15**	6
IF7	**0**	**4**	**2**	**2**	**2**	**3**	**3**	**2**	**0**	**2**	**20**	3
IF8	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	9
IF9	**0**	**5**	**3**	**1**	**5**	**5**	**2**	**2**	**0**	**2**	**25**	2
IF10	**3**	**4**	**5**	**1**	**5**	**4**	**4**	**3**	**0**	**2**	**31**	1
S	**11**	**22**	**18**	**8**	**20**	**19**	**19**	**16**	**0**	**9**		
rank	7	1	5	9	2	3	3	6	10	8		

Figure 2: MICMAC matrices of the order 1-3 of the example in figure 1

Even without the interpretation of the ranking the drawback of the MICMAC method becomes clear that only the number of indirect impacts is considered but not the strength of the impacts. The method works only for 0 and 1 in the initial MICMAC matrix. Appropriately, according to Gausemeier et al. [12] the MICMAC method is only suitable for interdependency analysis but not really for impact analysis. Another point of critique is the ranking of the IFs. This is done when stability of the ranking is reached. However, only the numbers of indirect impacts in that special stage are considered and all other numbers of indirect impacts with shorter chain length are omitted. There is no rule which stage is necessary to reach stability.

Another method with a modified impact matrix for the consideration of indirect impacts is mentioned by Gausemeier et al. [12]. The method is not described in detail but the main difference to the MICMAC method is that only one indirect impact matrix is generated and that the main diagonal of that matrix is filled with 0. Thus, indirect impacts from an impact factor on itself are omitted.

	IF1	IF2	IF3	IF4	IF5	IF6	IF7	IF8	IF9	IF10	S	rank
IF1	**6**	**14**	**11**	**6**	**11**	**12**	**13**	**11**	**0**	**7**	**91**	4
IF2	**3**	**2**	**4**	**1**	**2**	**1**	**4**	**2**	**0**	**1**	**20**	8
IF3	**2**	**9**	**4**	**4**	**6**	**8**	**6**	**6**	**0**	**4**	**49**	7
IF4	**8**	**10**	**12**	**4**	**9**	**8**	**12**	**8**	**0**	**5**	**76**	6
IF5	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	9
IF6	**9**	**12**	**13**	**5**	**11**	**9**	**14**	**10**	**0**	**5**	**88**	5
IF7	**8**	**18**	**11**	**8**	**14**	**15**	**15**	**14**	**0**	**7**	**110**	3
IF8	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	9
IF9	**7**	**19**	**10**	**9**	**14**	**16**	**16**	**17**	**0**	**8**	**116**	2
IF10	**13**	**22**	**20**	**10**	**18**	**17**	**24**	**19**	**0**	**10**	**153**	1
S	**56**	**106**	**85**	**47**	**85**	**86**	**104**	**87**	**0**	**47**		
rank	7	1	5	8	5	4	2	3	10	8		

	IF1	IF2	IF3	IF4	IF5	IF6	IF7	IF8	IF9	IF10	S	rank
IF1	**19**	**30**	**27**	**13**	**25**	**24**	**31**	**24**	**0**	**13**	**206**	4
IF2	**2**	**9**	**4**	**4**	**6**	**8**	**6**	**6**	**0**	**4**	**49**	8
IF3	**12**	**14**	**17**	**6**	**13**	**10**	**18**	**12**	**0**	**6**	**108**	7
IF4	**13**	**29**	**19**	**13**	**22**	**24**	**25**	**22**	**0**	**12**	**179**	6
IF5	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	9
IF6	**14**	**32**	**22**	**14**	**25**	**27**	**28**	**25**	**0**	**14**	**201**	5
IF7	**22**	**34**	**33**	**15**	**29**	**26**	**38**	**29**	**0**	**15**	**241**	3
IF8	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	9
IF9	**24**	**34**	**36**	**15**	**29**	**26**	**40**	**29**	**0**	**16**	**249**	2
IF10	**27**	**53**	**42**	**23**	**42**	**44**	**50**	**41**	**0**	**24**	**346**	1
S	**133**	**235**	**200**	**103**	**191**	**189**	**236**	**188**	**0**	**104**		
rank	7	2	3	9	4	5	1	6	10	8		

	IF1	IF2	IF3	IF4	IF5	IF6	IF7	IF8	IF9	IF10	S	rank
IF1	**37**	**72**	**56**	**32**	**57**	**58**	**69**	**57**	**0**	**31**	**469**	4
IF2	**12**	**14**	**17**	**6**	**13**	**10**	**18**	**12**	**0**	**6**	**108**	8
IF3	**16**	**41**	**26**	**18**	**31**	**35**	**34**	**31**	**0**	**18**	**250**	7
IF4	**36**	**57**	**54**	**25**	**48**	**44**	**62**	**47**	**0**	**25**	**398**	6
IF5	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	9
IF6	**41**	**64**	**60**	**28**	**54**	**50**	**69**	**53**	**0**	**28**	**447**	5
IF7	**41**	**85**	**64**	**37**	**67**	**71**	**78**	**66**	**0**	**38**	**547**	3
IF8	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	9
IF9	**42**	**91**	**65**	**40**	**70**	**76**	**81**	**69**	**0**	**40**	**574**	2
IF10	**68**	**116**	**100**	**51**	**95**	**92**	**118**	**93**	**0**	**50**	**783**	1
S	**293**	**540**	**442**	**237**	**435**	**436**	**529**	**428**	**0**	**236**		
rank	7	1	3	8	5	4	2	6	10	9		

Figure 3: MICMAC matrices of the order 5-7 of the example in figure 1

3. The ADVIAN® method

In order to overcome the drawbacks of the state-of-the-art methods and to consider both indirect impacts and their strengths, an enhanced approach was developed. We will first summarise the method and then give some simple but instructive examples for the direct comparison of the state of the art and the ADVIAN® method. The ADVIAN® method can be used with the commonly used impact strength 0, 1, 2, 3; however, other (positive) impact strengths can be used as well (for instance 0-5 for a finer scale, see [1]). The results of the complex calculations needed for the method were carried out using a self-developed Microsoft™ Excel Add-in.

3.1 Approach for the consideration of indirect impacts and their impact strengths

The ADVIAN® method makes use of both active and passive sums as well as the consideration of indirect impacts. However, the original impact matrix is not changed. The basic idea is that in indirect relations also the impact strength of the corresponding impact factor has to be considered. Therefore, we define different orders of 'activity' and 'passivity'. The activity (passivity) of the 1st order equals the active sum (passive sum) of the state-of-the-art methods and therefore considers only direct impacts. For example, in a system with 5 IFs (IF1, IF2, IF3,

IF4, IF5) the activity of 1st order for IF1 sums up the strengths of IF1⇒IF2, IF1⇒IF3, IF1=IF4, IF1⇒IF5. Then, the activity (passivity) of the 2nd order takes into account the 1st order activity (passivity) but also the indirect impacts with a step length of 2 (for the indirect impact of IF1 on IF2 all the following chains have to be considered: IF1⇒IF3⇒IF2, IF1⇒IF4⇒IF2, IF1⇒IF5⇒IF2). The 3rd order activity (passivity) again takes into account the 2nd order activity (passivity) and the indirect impacts with a step length of 3. Higher orders are built accordingly. If the order is the number of impact factors minus 1 then all possible indirect impacts with chains having only different IFs have been considered (for example indirect chain IF1⇒IF2⇒IF3⇒IF4⇒IF5). Our new active sum (passive sum) is the sum of all activities (passivities) up to the considered order. In order to distinguish between the state of the art and the ADVIAN® method we will call the sums 'direct active sum' ('direct passive sum') for the state of the art and 'indirect active sum' ('indirect passive sum') for ADVIAN®. The examples in the next section will aid in understanding the method.

3.2 Simple examples for the comparison to state-of-the-art approaches

3.2.1 Comparison to classical impact analysis

The following example explains the ADVIAN® method by use of one of the simplest impact matrices. There are only 4 impact factors IF1, IF2, IF3, IF4 and we suppose that we have only the following impacts IF1⇒IF2, IF2⇒IF3, IF3⇒IF4 and give them the strength of 1.

		on				Activity			
	Impact from	**1**	**2**	**3**	**4**	direct sum	2. order	3. order	indirect sum
	1	**0**	1	0	0	1	1	1	3
	2	0	**0**	1	0	1	1	0	2
	3	0	0	**0**	1	1	0	0	1
	4	0	0	0	**0**	0	0	0	0
Passivity	direct sum	0	1	1	1				
	2. order	0	0	1	1				
	3. order	0	0	0	1				
	indirect sum	0	1	2	3				

Figure 4: Simple example for the explanation of the ADVIAN® method

The direct active sums of IF1, IF2, and IF3 are all equal to 1 and the state of the art would assign the same importance to all three IFs. However, since there are indirect relations in the form IF1⇒IF2⇒IF3, IF2⇒IF3⇒IF4, and IF1⇒IF2⇒IF3⇒IF4 the conclusion is that the IF1 is the most important factor because it has an (indirect) impact on all others. This result is obtained with the ADVIAN® method. There are differences in the 2nd and 3rd order activity and the indirect active sum is the highest for IF1, the second highest for IF2, then IF3 and at the end IF4. At the same time, looking at the passivities, we recognise that the IF4 is indeed the most influenced one, while the direct passive sum of the state of the art assigns the same dependence to IF2, IF3, and IF4.

In the next step we will change the impact strength IF2⇒IF3 to 2 and IF3⇒IF4 to 3 and obtain the results shown in figure 5.

		on				Activity			
	Impact from	**1**	**2**	**3**	**4**	direct sum	2. order	3. order	indirect sum
	1	**0**	1	0	0	1	2	6	9
	2	0	**0**	2	0	2	6	0	8
	3	0	0	**0**	3	3	0	0	3
	4	0	0	0	**0**	0	0	0	0
Passivity	direct sum	0	1	2	3				
	2. order	0	0	2	6				
	3. order	0	0	0	6				
	indirect sum	0	1	4	15				

Figure 5: Simple example with modified impact strengths

The direct active sum (state of the art) with neglected indirect impacts gives the order of importance for the optimisation of the system: IF3, IF2, IF1, IF4. However, considering indirect impacts with the ADVIAN® method we get a different order IF1, IF2, IF3, IF4. Looking more closely at the example, this order is more justified. Although the impact strength of IF1 on IF2 is only 1 the IF1 is the start of a chain of impacts and therefore is a key impact factor (for the ADVIAN® classification see [8]).

Now we will apply the ADVIAN® method to the short example given in the literature ([16], p. 146). The results are shown in figure 6.

	on										Activity					
Impact from	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	direct sum	2. order	...	indirect sum	rank direct	rank indirect
1	**0**	3	1	3	0	0	2	2	0	1	12	98	...	153409303	2	2
2	1	**0**	3	0	2	1	0	1	0	0	8	47	...	66069435	5	7
3	0	2	**0**	0	3	2	0	0	0	0	7	36	...	52022267	7	8
4	0	3	3	**0**	0	0	2	0	0	0	8	63	...	86603165	5	6
5	0	0	0	0	**0**	0	0	2	0	0	2	6	...	13563390	10	10
6	3	0	0	0	1	**0**	2	1	0	0	7	59	...	109305366	7	5
7	1	1	1	1	0	2	**0**	1	0	2	9	90	...	148559718	3	3
8	0	0	1	1	0	0	0	**0**	0	1	3	34	...	50981874	9	9
9	1	3	0	3	0	0	0	0	**0**	2	9	98	...	146375999	3	4
10	3	3	3	2	0	1	3	3	1	**0**	19	149	...	244931799	1	1
direct sum	9	15	12	10	6	6	9	10	1	6						
2. order	61	111	121	61	72	63	68	78	6	39						
...	...	...	...	...	...	...	...	...	...	...						
indirect sum	102710273	165268852	172635563	92350926	126600354	103684119	103914492	135062831	8158248	61436658	Passivity					
rank direct	5	1	2	3	7	7	5	3	10	7						
rank indirect	7	2	1	8	4	6	5	3	10	9						

Figure 6: ADVIAN® method applied to the example in figure 1. Activities and passivities were calculated up to the 9th order.

In this example, the order of the IFs according to their active sum does not change drastically. However, we see a significant change in the order of passive sums (IF4 and IF5). A graphical presentation is more expressive. Figure 7 shows the change from direct to indirect sums for the example in figure 1. In order to make the direct and indirect sums comparable the sums were standardised to the maximum of active and passive sum (maximum of direct active and passive sum is set 100, maximum of indirect active and passive sum is set 100). It is not an aim of this paper to discuss the effect of the change in active and passive sums under consideration of indirect impacts on the interpretation of the given model.

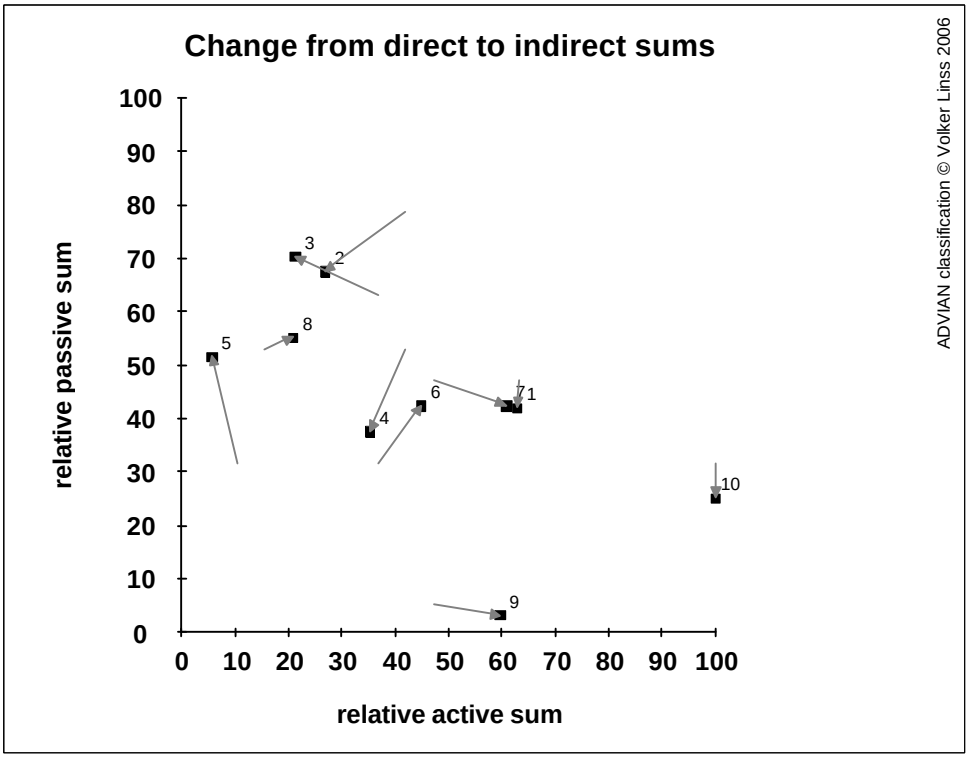

Figure 7: Relative active and passive sums of the example in figure 1 with the changes by considering also indirect impacts. For the numbering of the IFs see figure 1.

3.2.2 Comparison to the MICMAC method

An example like in figure 4 cannot be treated with the MICMAC method. Figure 8 shows the MICMAC matrix and the matrix raised to the power of 2 and 3. The requested stability in ranking is not reached because from the power 4 onwards the resulting matrices are filled with the number 0.

on

Impact from	1	2	3	4	active sum	rank
1	0	1	0	0	1	1
2	0	0	1	0	1	1
3	0	0	0	1	1	1
4	0	0	0	0	0	4
passive sum	0	1	1	1		
rank	4	1	1	1		

Impact from	1	2	3	4	active sum	rank
1	0	0	1	0	1	1
2	0	0	0	1	1	1
3	0	0	0	0	0	3
4	0	0	0	0	0	3
passive sum	0	0	1	1		
rank	3	3	1	1		

Impact from	1	2	3	4	active sum	rank
1	0	0	0	1	1	1
2	0	0	0	0	0	2
3	0	0	0	0	0	2
4	0	0	0	0	0	2
passive sum	0	0	0	1		
rank	2	2	2	1		

Figure 8: MICMAC matrices of the order 1-3 of the very simple example given in figure 4. The MICMAC matrices from order 4 are filled with „0“.

The stability in ranking may not be reached even if the elements of the MICMAC matrix of the n^{th} order are not 0. We will now consider a fictitious example. Suppose the first matrix in figure 9 is an impact matrix of a given problem. For the treatment with the MICMAC method this matrix has to be modified and we obtain the second matrix in figure 9 (we set 0 and 1 in the impact matrix to 0 in the MICMAC matrix and 2 and 3 in the impact matrix to 1 in the MICMAC matrix). Figure 9 shows the MICMAC matrices up to the power of 3. A strong variation in the ranking of the „active sums“ is found. This ranking never stabilises as shown in figure 10 for powers of the MICMAC matrix up to 20. The ranking oscillates. The ADVIAN® method leads to a stable result also in this case (without figure).

on

Impact from	1	2	3	4	5	6
1	0	1	0	2	3	2
2	1	0	0	1	2	2
3	0	1	0	1	0	2
4	2	1	1	0	1	0
5	3	1	0	1	0	0
6	2	3	0	1	1	0

on

Impact from	1	2	3	4	5	6	active sum	rank
1	0	0	0	1	1	1	3	1
2	0	0	0	0	1	1	2	2
3	0	0	0	0	0	1	1	4
4	1	0	0	0	0	0	1	4
5	1	0	0	0	0	0	1	4
6	1	1	0	0	0	0	2	2
passive sum	3	1	0	1	2	3		
rank	1	4	6	4	3	1		

on

Impact from	1	2	3	4	5	6	active sum	rank
1	3	1	0	0	0	0	4	2
2	2	1	0	0	0	0	3	3
3	1	1	0	0	0	0	2	6
4	0	0	0	1	1	1	3	3
5	0	0	0	1	1	1	3	3
6	0	0	0	1	2	2	5	1
passive sum	6	3	0	3	4	4		
rank	1	4	6	4	2	2		

on

Impact from	1	2	3	4	5	6	active sum	rank
1	0	0	0	3	4	4	11	1
2	0	0	0	2	3	3	8	2
3	0	0	0	1	2	2	5	4
4	3	1	0	0	0	0	4	5
5	3	1	0	0	0	0	4	5
6	5	2	0	0	0	0	7	3
passive sum	11	4	0	6	9	9		
rank	1	5	6	4	2	2		

Figure 9: Fictitious example of an impact matrix and the according MICMAC matrices of the order 1-3

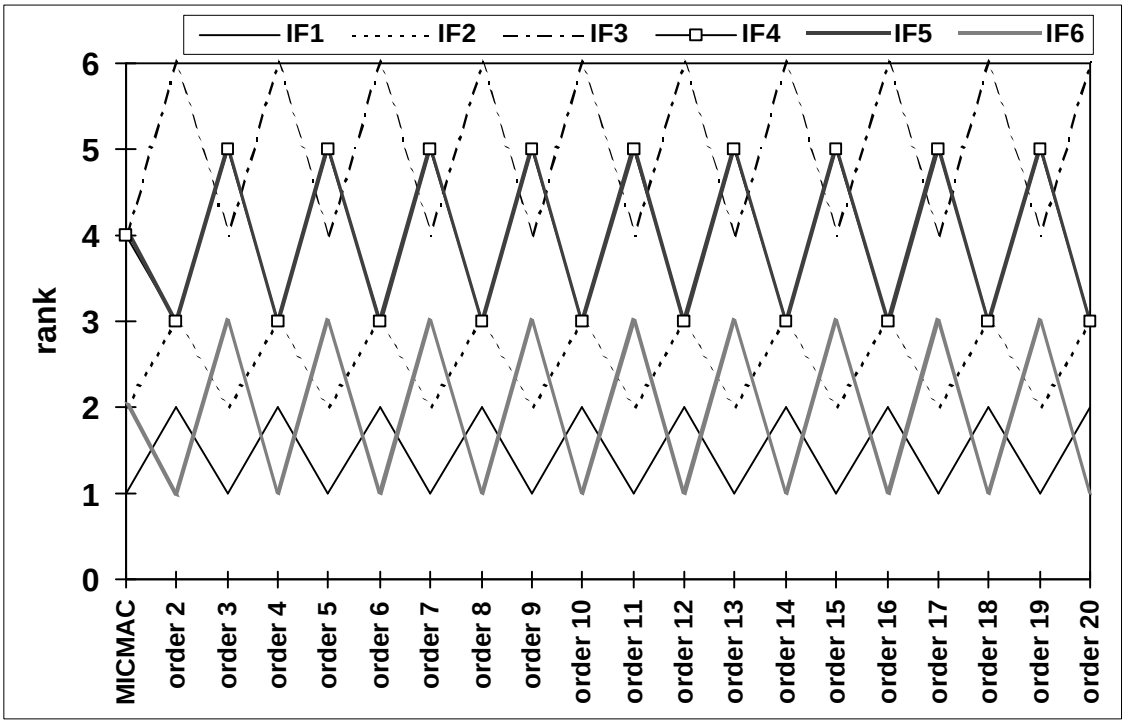

Figure 10: Rankings of the example in figure 9 for the MICMAC matrices of the orders 1-20

The last example is again the automotive industry example from figure 1. The MICMAC ranking of the „active sums“ is stable from the MICMAC matrix with the power of 6. In order to compare the same depth of indirect impacts, figure 11 shows the MICMAC matrix of the 9th order (see ADVIAN® matrix in figure 6). Figure 11 compares the rankings for the MICMAC method, the „Papiercomputer“ and the ADVIAN® method. The rankings are different. The examples above have shown that the methods may differ greatly. For the interpretation of the ranking the reader is again referred to another paper [8].

on

Impact from	1	2	3	4	5	6	7	8	9	10	active sum	rel. AS	rank
1	194	361	293	158	291	293	351	286	0	158	2385	59.7	4
2	53	78	77	34	67	60	87	65	0	34	555	13.9	8
3	94	198	146	87	155	164	181	154	0	87	1266	31.7	7
4	178	299	263	131	247	237	308	242	0	130	2035	51.0	6
5	0	0	0	0	0	0	0	0	0	0	0	0.0	9
6	198	336	295	147	277	267	345	271	0	147	2283	57.2	5
7	220	426	337	187	340	347	408	336	0	187	2788	69.8	3
8	0	0	0	0	0	0	0	0	0	0	0	0.0	9
9	227	450	350	197	358	369	425	353	0	198	2927	73.3	2
10	336	595	505	260	486	478	596	476	0	261	3993	100.0	1
passive sum	1500	2743	2266	1201	2221	2215	2701	2183	0	1202			
rel. PS	37.6	68.7	56.7	30.1	55.6	55.5	67.6	54.7	0.0	30.1			
rank	7	1	3	9	4	5	2	6	10	8			

Papiercomp.	5	1	2	3	7	7	5	3	10	7
ADVIAN	7	2	1	8	4	6	5	3	10	9

Papierc.	ADVIAN
2	2
5	7
7	8
5	6
10	10
7	5
3	3
9	9
3	4
1	1

Figure 11: MICMAC matrix of the 9th order of the example in figure 1 and comparison of the ranks of the IFs to the „Papiercomputer“ and ADVIAN® method

4. Conclusions

A new method for the impact analysis, the ADVIAN® method, has been introduced. The intention is to forward the impact analysis in the strategic management field. The new method was put forward because formerly developed methods in future research analysis have some striking disadvantages. The article here refers to Vester's "Papiercomputer" and the MICMAC method as the most prominent representatives. The "Papiercomputer" does not consider indirect impacts at all whereas the MICMAC method has limitations in terms of the results' stability and the possible differentiation of assignments given by its users. The ADVIAN® method overcomes these limitations. It is based on classical methods but considers indirect impacts as well as their impact strengths. In principle, the impact strength is not limited to 0, 1, 2, 3. The impact matrix does not have to be modified before the calculations. For the consideration of indirect impacts with the ADVIAN® method there is no reduction of the impact strength to 0 and 1 needed nor a new calculation of the elements of the IM has to be carried out. Simple examples have shown that some of the drawbacks of classical impact analysis methods could be avoided. The ADVIAN® method is suitable for the identification of the key impact factors. However, the classification of the impact factors will be the topic of another paper [8].

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